1. **Project Name:** **High Density Infrared Surface Treatments of Refractories**

2. **Lead Organization:** Oak Ridge National Laboratory
Oak Ridge, TN 37831-6087

3. **Principal Investigator:** Terry Tiegs
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Co-Investigators:
Craig Blue
Dave Harper
Fred Montgomery

4. **Project Partners:** University of Missouri – Rolla (subcontractor)
M. Velez and R. M. Moore

Allied Mineral, Inc. (material supplier)
Dana Goski

Emhart Glass Co. (material supplier)
Steve Herrington

Magneco-Metrel, Inc. (material supplier)
Mike Anderson

5. **Date Project Initiated and FY of Effort:** October 1, 2001 (FY2002)

6. **Expected Completion Date:** September 30, 2004

7. **Project Technical Milestones and Schedule:**

The overall goals of the project are to make a major advancement in improving the behavior of refractory materials used in industrial processing. Refractories play an integral part in the operations of numerous industries of the future and any advancement could have a significant and large impact on the viability of those industries. The benefits of HDI processing of refractories would be to: (1) reduce surface porosity (by essentially sealing the surface to prevent liquid penetration), (2) allow surface chemistry changes that would inhibit wetting and/or corrosion, and (3) improve mechanical properties.

ID Number	Task / Milestone Description	Planned Completion	Actual Completion	Comments
1	Demonstrate surface porosity reduction on oxide-based refractories and show improved corrosion resistance in simulated process environments.	9/30/02	9/30/02	Completed
2	Fabricate corrosion-resistant surface layers on refractories by either diffusion coating or selective sintering of secondary layers.	9/30/03		On schedule
3	Produce refractories having high emissivity surface coatings.	9/30/04		Pending

8. **Past Project Milestones and Accomplishments:**

FY 2002 Summary - HDI treatment of commercial refractories showed that surface melting was plainly evident at moderate power levels (=1375 watts/cm^2) for the aluminosilicate based materials. The more refractory high alumina compositions required power levels =2025 watts/cm^2 to produce melted surfaces. During solidification of the surface melted region on alumino-silicate materials, the mullite grains that formed were highly oriented with the c-axis perpendicular to the surface. Preliminary corrosion testing showed the HDI treatment was effective in reducing penetration by molten copper.

FY 2003 Activities – Current activities are examining changes in surface chemistry by either diffusing desired species into the surface or bonding an adherent coating onto the underlying refractory that would inhibit wetting and/or corrosion. To date, adherent surface coatings of spinel and zirconia have been applied to an alumino silicate refractory.

9. **Planned Future Milestones:**

The plan for work is to complete preparation of coated refractory samples of multiple compositions, including aluminosilicates, aluminum zirconium silicates (AZS), and silica. Corrosion testing in glass will then be done at the University of Missouri-Rolla. Starting in October, work will be initiated on producing refractories with high emissive surfaces.

10. **Issues/Barriers:**

No technical barriers appear to be a problem. However, economic barriers to application of the technology are present. Near-term use will concentrate on applications that require high performance and can justify the increased cost of refractories.

11. **Intended Market and Commercialization Plans/Progress:**

Samples of high density infrared surface treated refractories will be supplied to companies for testing at their facilities. The initial samples will be supplied to Emhart for testing in a glass application in the June 2003 timeframe.

12. **Patents, publications, presentations:**

Patents
Invention disclosure filed with UT-Battelle patent office. September 2002.

Publications
1. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, C. A. Blue, "HDI Surface Treatment of Ceramics," Am. Ceram. Soc. Bull., 82 [2] 49-53 (2003).

2. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, C. A. Blue, "High Density Infrared Surface Treatment of Ceramics," Ceram. Transactions, Vol. 135, 239-246, Am. Ceram. Soc., Westerville, OH (2002).

3. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, D. C. Harper, and C. A. Blue, "Surface Modification of Ceramics By High Density Infrared Heating," to be published in Ceram. Eng, Sci. Proceed., Am. Ceram. Soc., Westerville, OH (2003).

Presentations
1. Presentation made at the American Ceramic Society Annual Meeting in St. Louis, MO, April 29-May 1, 2002 entitled, "High Density Infrared Surface Treatment of Ceramics."

2. Presentation made at the American Ceramic Society Pacific Coast Meeting in Seattle, WA Oct. 1-4 entitled," Surface Treatment of Refractories By High Intensity Infrared Heating."

3. Presentation made at the American Ceramic Society Meeting on Advanced Materials in Cocoa Beach, FL, Jan, 27-31, entitled," Surface Modification of Ceramics By High Density Infrared Heating."

Highlight

Surface Modification of Refractories

- PI - T. N. Tiegs (ORNL)
- Partners - Univ. Missouri-Rolla, Allied Mineral, Emhart Glass

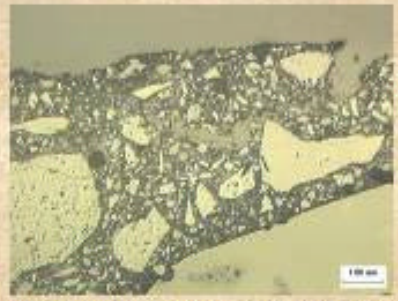
Project Goals:

(1) reduce surface porosity (by essentially sealing the surface to prevent liquid penetration), (2) allow surface chemistry changes that would inhibit wetting and/or corrosion, and (3) improve mechanical properties.

Visual Appearance of High Alumina Castable

- Scan rate of 1 cm/sec

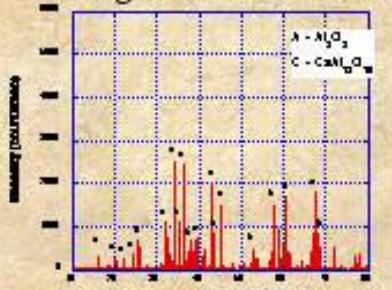
Surfaces of High Alumina Castable



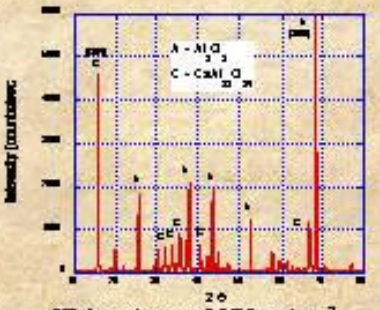
Conventional heating 1500° C for 1 hour

IR heating at 2350 w/cm² (Dual Scan)

IR Heating Shows Formation of Highly Oriented Phases in High Alumina Castable



Conventional heating 1500° C for 1 hour



IR heating at 2350 w/cm²